

Running head: HIGH-RISE EVACUATION OF ELDERLY

Leading Community Risk Reduction

Study on High-rise Evacuation of  
Elderly Residents during Fire Alarms

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### Abstract

The problem was there were no evacuation plans to direct the actions of elderly residents living in high-rise apartment buildings in Galesburg. The purpose of the research was to identify current behavior of residents during fire alarms while evaluating methods and technologies that could improve the protection and evacuation of the risk group. A literature review, alarm history, survey, and fire drill answered these questions using descriptive research: 1) what is the current behavior of residents during fire alarms? 2) what have others done to improve evacuation of elderly high-rise residents? 3) what technologies are available to improve fire protection of high-rise residents? The results reveal a need for enhanced fire and evacuation planning by fire officials and building managers.

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## Introduction

Throughout the history of the United States Fire Service, the reputation of the successful fire department has been reflected in its record of protecting its citizens from the ravages of fire. At “routine” fires in single-family dwellings, the job of rescuing and removing endangered occupants is difficult at best. In situations where residents less capable of aiding with their own evacuation are housed in complex living arrangements, the challenge to the local fire department becomes extreme. Such is the case where elderly citizens reside in high-rise buildings. The potential for tragedy in these housing units makes it imperative that fire officials coordinate with building staff and residents to formulate plans for fire protection and evacuation of these facilities in the case of fire.

The problem is that the Galesburg Fire Department has no evacuation plans to direct the actions of elderly residents living in high-rise apartment buildings. These plans could minimize the loss of life and injury during fires at these occupancies within the city. The purpose of the research is to identify current behavior of elderly high-rise residents in Galesburg during fire alarms and to research and assess methods that could improve evacuation and fire protection of this risk group.

The study will implement a descriptive research methodology to answer the following questions:

1. What is the current behavior of elderly residents during fire alarms at high-rise buildings in Galesburg?
2. What have others done to improve evacuation of elderly residents in high-rise buildings?

3. What new technology or engineering controls are available to improve high-rise safety for elderly residents?

The author plans to answer Question #1 by surveying high-rise residents and conducting fire drills in the targeted buildings. A literature review will be used to answer Questions #2 and #3.

### Background and Significance

In what has become known as the “graying of America”, the United States is rapidly becoming a nation of the elderly. Older adults, those over 64 years of age, currently number 34 million and represent 12% of the population, a proportion that is expected to rise to 20% in the next 40 years (Bureau of the Census, 1995). In the year 1997, almost 2 million Americans celebrated their 65<sup>th</sup> birthday while only 1.7 million Americans in this age group died (United States Fire Administration [USFA], 2004). Advancements in health care and medicine have increased the average life expectancy of 21<sup>st</sup> century Americans to nearly 80 years of age, a steady rise of 5 years since 1970 (Department of Health and Human Services, 1998). As the baby boom generation moves toward social security, the country will be forced to sharpen its focus on issues concerning the swelling number of its elderly citizens. Likewise, emergency service providers will need to evaluate current and future plans for mitigating emergencies involving the aging population. In response to the growing problem, the USFA promotes the reduction of loss of life in the age group of 65 and over in its Operational Objectives. The USFA challenges the fire service organization to take a leading role in promoting comprehensive, multi-hazard risk-reduction on the local level. Accordingly, Executive Fire Officers should anticipate a continued growth in elderly-related incidents in their own communities and be proactive in safety education programs such as evacuation planning in facilities housing these individuals.

As a line officer with 20 years of experience responding to fire alarms in high-rise buildings with elderly populations, the author has noted the potential for catastrophe that exists. With little or no on-site staff available and a normal fire response of 12 personnel, the local department would be greatly challenged to react successfully in the event of a well-developed fire in a high-rise occupancy in the author's community. The tragic events of September 11, 2001, and the recent fatal fires in high-rise buildings in Chicago, Illinois, highlight the difficulties faced by fire companies in rescuing occupants from multi-floor occupancies. The courageous efforts of emergency personnel at the time of a fire cannot supplant the value of a proactive plan for coordinating the behavior of occupants and responders in order to save lives in these buildings, no matter the size of the jurisdiction. One of the goals of the Executive Fire Officer Program's Leading Community Risk Reduction course is to encourage fire officers to promote and champion new ways of reducing risk in their community. The author intends to take the lead in identifying better ways to protect the elderly citizens in Galesburg that live in high-rise facilities by first evaluating the current risk and then seeking intervention strategies that have proven effective by others.

Older adults, those over 65 years of age, represent one of the highest fire risk groups in the United States in large part because they are the fastest growing segment of the population. According to USFA statistics (2004), over 1200 of these senior Americans die as a result of fire each year as reflected in proportion to the national average:

- Persons who are 65 to 75 have a fire death rate twice that of the national average
- between 75 and 85 the death rate is three times the national average
- for those over 85, the death rate is four times the national average

In addition, older adults are affected by an average of 3,000 injuries resulting from residential fires each year.

There are many causes that account for the high number of elderly-related incidents across the country. Fires caused by smoking are the leading cause of fire deaths in the elderly, a number attributed to the 15% of the elderly population who smoke some form of tobacco. Medications used by those with emphysema and lung cancer often cause drowsiness, another factor in fires started by the elderly. Cooking is also a leading cause of fire deaths and injuries in this age group as common scenarios involve loose-fitting clothing and forgetting food on the stove. In colder climates, older citizens with poor thermoregulation are known to make extensive use of alternate or temporary heat sources, often with little regard to fire or electrical hazards. While the majority of elderly fire victims succumb to smoke inhalation, they also tend to be in close contact with the source of the fire, as they are often killed when their clothing, bedding, or upholstery ignite (USFA, 2005).

As the human body ages, there is most often the associated disabilities and progressive degeneration in physical, cognitive, and emotional capabilities that challenge elderly individuals to care for themselves and their surroundings. The elderly often experience diminished visual acuity, depth perception, hearing, and sense of smell, as well as deficits in mobility and balance. The inability to smell smoke, hear fire alarms, and read evacuation and other safety-related information limit the response by older citizens in emergencies. Dementia and age-related neurological difficulties, such as Alzheimer's disease, impair memory, thinking, and behavior making these individuals significantly more susceptible to injury and death from fire. Other variables such as depression and alcohol consumption contribute to the risk as well.

Perhaps the greatest hurdle in evacuation planning is found in the inability of disabled individuals to move to a place of refuge when the need arises. The need for assistance to get occupants to stairwells, elevators, or other safe areas during fires is a dynamic situation influenced by the ever-changing status of the health, location, and attitude of the residents themselves. Therefore, building managers and fire officials must remain vigilant in maintaining a roster of those individuals who are non-ambulatory or require special assistance should an evacuation be necessary.

In an effort to provide more housing in valuable living space, high-rise structures have been an answer in many communities. A high-rise building is often defined as an occupied structure for which the roof access level exceeds the maximum height of rescue capability from street level by fire department ground leaders (National Safety Council [NSC], 2005). Dunn (1999, May) echoes the general description held by most authorities that a high-rise building is any structure over 75 feet in height.

The ability to house individuals in small apartment type living arrangements has been a growing trend in the last 50 years in many communities across the country. Elderly individuals, especially those who live alone, have found these multi-floor residences, with their small apartments and social atmosphere, attractive for their limited needs. However, in light of recent global events, a sense of insecurity has swept through these residential communities. The fire and rescue challenges that result through the coupling effect of housing older adults in high-rise occupancies are well-known to fire officials worldwide. The major difficulty in simultaneously performing rescue and firefighting operations in these buildings is one of access. As the building residents, many who may need assistance, struggle to move to a place of safety via elevators and



stairwells, emergency responders attempt the laborious task of getting manpower and equipment up these same elevators and stairwells to control the fire and rescue occupants in peril.

The protection of high-rise occupants must be made a part of every full-service fire safety program. The ability to make high-rise living a protected and dependable residential lifestyle can be a complex endeavor, but it can be done. Countless safety features already exist in most residential environments. Harville (2003, July/August) notes that advances in building construction, sophisticated fire protection and detection systems, and fire apparatus have helped to make buildings more “people-safe.” Building codes have evolved to make sure tenants and other occupants are protected by mandating sprinklers, extinguishers, emergency lighting systems, and posted floor plans. Regardless of these improvements, fires happen. People cause fires by their acts of commission and omission, furnishings feed fires, and panic results in needless loss of lives and injuries. Without adequate evacuation programming and planning, and complete “rehearsal for survival” drills, lives will continue to be lost in residential high-rise fires (NSC, 2005).

The trend toward an aging national population is reflected on the local level in the rural area of west-central Illinois in the city of Galesburg. Located 30 miles east of the Mississippi River, the city covers approximately 18 square miles, has a population of 33,000, and serves as the county seat of Knox County. The citizenry includes an elderly population of 6,093 residents, representing 18.1% of those calling Galesburg home. Nearly 1 in 3 households (31.3%) includes an elderly resident; approximately one-half of these older citizens (16.1%) live alone (USACityLink, 2005).

The city of Galesburg is served by a full-time career fire department of 48 sworn personnel operating out of three fire stations. With an average daily manning level of 12 line

firefighters working 24-hour shifts, the Galesburg Fire Department (GFD) responds to structure fires and vehicular accidents, maintains a hazardous materials response team, and provides non-transport emergency medical service at the basic life support level. Additionally, fire prevention is accomplished through inspections, code enforcement, and public education programs by shift personnel supported by four 40-hour personnel. The city maintains an Insurance Services Office (ISO) rating of 3.

The elderly population of Galesburg is spread throughout the community in a variety of living arrangements, ranging from single-family dwellings to assisted-living communities to nursing homes. A large proportion of these older citizens who are capable of caring for their own self can be found in four residential buildings over five stories in height: Moon Towers, Mary Allen West Tower, Galesburg Towers, and The Kensington. These buildings range from 6-14 stories in height with a total of 454 available apartments. These apartments typically contain no more than 3 rooms; approximately 95% of these units have a resident living alone with a median age of 71 years. With very few exceptions, the units are occupied by senior citizens as regulated by the county housing authority. Statistical data on fire alarms in these buildings over the most recent four-year period can be found in Appendix A.

Though each is unique in design, these facilities are similar from a fire protection standpoint. Moon Towers, Mary Allen West Tower, and Galesburg Towers were built in the 1960's. The concrete and brick construction of these buildings provides a fire-resistive structure that limits fire loading to the contents placed in them. The three tower facilities are equipped with automatic sprinkler systems designed to control fire spread. The Kensington, a refurbished older building that once housed the Custer Hotel, provides for more upscale living but does not have sprinklers on its resident floors. All four of these high-rise buildings have enclosed

stairwells to aid in occupant egress, as well as fire detection and alarm systems with direct ties to the Galesburg/Knox County Dispatch Center. Building standpipe systems are provided on all floors in these buildings to speed the availability of a water supply to responding fire units for attacking fires in all buildings. Elevators equipped with emergency operation features are common to all buildings as well as automated self-closing fire doors to limit the spread of smoke within floors. In addition, emergency lighting systems are present to assist occupant evacuation and HVAC systems are linked to fire alarms to prevent extension of fire and smoke to uninvolved areas.

The City of Galesburg has adopted the 2000 International Fire Code. Section 404 of this code, “Fire Safety and Evacuation Plans”, requires high-rise buildings to prepare and maintain fire safety and evacuation plans. These plans must include:

- floor plans showing primary and secondary emergency egress or escape routes
- areas of refuge
- procedures for operating critical equipment before evacuating
- procedures for accounting for employees and occupants
- a means of notifying occupants of a fire or emergency
- assignment of personnel responsible for rescue
- life safety strategy for notifying, relocating, or evacuating occupants
- normal routes for fire department vehicle access
- a list of major hazards associated with the premises
- assignment of personnel responsible for maintenance of fire protection systems

The code requires these plans to be reviewed or updated annually or as necessitated by changes in staff assignments, occupancy, or physical arrangement of the building. (International Code

Council, 1999). The Fire Department has conducted some public education with the residents of these facilities, but this has been very infrequent over the last 25 years; these talks typically involve general fire safety tips or suggested actions to take during fires. There is no formal Fire Safety and Evacuation Plan for complying with the aforementioned requirements for any of the four buildings.

## Literature Review

### Behavior

In order to plan a fire protection strategy for high-rise elderly housing, it is important to predict the behavior of residents responding to fires alarms. In particular, the awareness and response of residents in any apartment building has a great impact on the evacuation process. In the wake of recent high-rise tragedies in New York and Chicago, the public has shifted from a feeling of apathy to apprehension in regards to safety and survivability in these buildings. The invincibility of high-rise structures, the use of defend-in-place strategies, and the ability of fire units to rescue occupants have all come into question in recent years.

The belief that people will panic in fire situations has been examined by psychologists and behaviorists. Although the media are very fond of this concept for its drama and sensational connotation, there is little evidence of panic in actual fire situations. Marchant (1972) found that most people do not panic in reaction to fire, especially in buildings that have fire protection systems with which they have become familiar. Winerman (2004, September 8) believes that panic during fires is very rare. He explains that when people say they panicked, they really became fearful, not crazy or irrational. Studies by Gershon (2003) regarding the evacuation of the World Trade Center on September 11, 2001, found that without exception, evacuees reported calm, orderly evacuation. Panic is generally associated with dynamic situations where an

immediate threat to survival exists, such as when too many people are trying to flee a fire through too small an exit opening.

Human behavior is a product of experience and beliefs. Studies by Bryan (1991) and Proulx (2003) indicate that people react to incidents based on a series of cues. Whether a person will recognize and react to any particular cue, such as a ringing fire alarm bell, often depends on the attention and activity that he/she is performing at the time. People tend to assess cues in accordance with past experience and in the form of an optimistic expectance, often as a direct result of the individual's perception of his/her personal invulnerability. Brennan (1995) agrees that if a threat is ambiguous, a person will assume it to be mild as individuals tend to ignore or deny an unexpected and unpleasant event that has happened. On the contrary, Murphy (2002, September/October) found that many of the workers who stayed at their desks during the first hours of the 1993 World Trade Center bombing did not make the same decisions 8 years later. At the first sign of danger on the morning of September 1, 2001, these same workers made an immediate decision to leave the building. Much like the "boy who cried wolf", residents of buildings that have a history of false alarms become conditioned to take little action; humans are inertial creatures and the fire alarm is often not enough of a cue to get them to drop their everyday tasks and exit a building (Groner, 2000). Echoing this sentiment, Proulx (2003) believes the fire alarm signal is probably the least reliable cue of a fire because of the many false alarms, whereas the smell of burning, visible smoke or a warning by others would be more apt to produce a response by the occupant.

It is a natural inclination for people to attempt to gain as much information before responding to a fire alarm. With no immediate or perceived threat, residents will wait for more cues, such as the smell of smoke or another resident urging them to leave, before evacuating.

Proulx found that it takes an average of three minutes for people to begin leaving a high-rise apartment building. While this time may seem short, a rapidly developing fire and smoke condition can be deadly for slow-moving elderly residents. During this “pre-movement time”, occupants begin to investigate the reason for the alarm by making phone calls, looking out windows, or knocking on their neighbor’s door. Only when they have received other significant cues convincing them to evacuate, do they begin to take action. However, even then they may not begin to exit. Many return to their apartment to make phone calls to warn family, friends, and neighbors. Groner feels that people demonstrate altruistic behavior to strangers in emergencies, often putting themselves at great risk to do so; Gershon acknowledges this but adds that the willingness to assist others at a person’s own risk is linked to familiarity, finding that people are much more likely to help a friend or known acquaintance than strangers. Elderly residents in particular are more apt to collect personal belongings, care for pets, get medications, or change clothes. These activities can take several minutes. Interviews with actual fire incident evacuees by Allen (2003) reveal that the time from alarm to beginning to leave a building may exceed thirty minutes.

Response behavior is also dependent on the characteristics of the individual occupant. Elderly individuals, especially those with disabilities, have shown a myriad of behavior during emergencies, often based on attitude. Though Kailes (2002) advises those with disabilities to become involved in emergency planning by pushing local fire departments and building managers to make sure plans are in place for their special needs, the decision to stay or evacuate most often rests with the individual resident. On one end of the scale are those individuals who have resigned themselves to stay in their apartment regardless of circumstances outside their door. These individuals, because of physical ailments, mental incapacities, or fear of leaving the

security of their apartment can be counted on to use a shelter-in-place strategy unless forced by officials to evacuate. Other older adults, suffering the same ailments, realize their incapacities and are very proactive in planning their escape should the need arise. This group will most likely begin moving toward the hallway soon after the alarm sounds.

In general, humans tend to exhibit some common behavior when responding to fires. Research and studies of actual fires demonstrate that providing information through a voice communication system is one of the best ways to ensure immediate reaction by occupants as long as the messages are audible, intelligible, and credible. Contrary to some beliefs, occupants tend to immediately obey instructions received through voice communication systems. Post-incident data collected by the Institute for Research in Construction (IRC) indicates that occupants will follow instructions issued over voice-communication systems, especially if the information comes from an official source such as the fire department (2005). The IRC stresses that this information must include sufficient information in a timely fashion to allow occupants time to safely respond. On the other hand, people may tend to ignore “canned” directions from public address systems that they hear during routine fire drills. They may especially disregard instructions, even from authorities, when previous experience has instilled in them an instinct to act otherwise. This was seen in the attacks on the World Trade Center in 2001; many workers in the South Tower immediately evacuated following contrary announcements from authorities that the South Tower was safe and that they should return to work.

In the absence of official instructions during fire alarms, residents will fall back on behavior patterns established from previous alarms, training, or drills. People will generally leave a building by the most familiar exit, usually through the one by which they entered. Winerman (2004, September 8) and Johnson and Feinberg (1997) believe this is true even when

emergency exit signs are well marked. Although the reason for this has not been adequately researched, Groner (2005) hypothesizes that people prefer familiar routes because of a preference for certainty when making risky situations. To the contrary, high-rise residents do not exhibit this behavior. When the fire alarm sounds in these buildings, evacuating occupants usually have only two options – the stairwell or the elevator. Residents who live above the first floor most always use the elevator for their daily comings and goings; stairwells are scarcely used. However, when the fire alarm sounds, the opposite behavior is found as most will instinctively head for the safety of the stairwell.

The use of elevators for emergency egress in high-rise buildings is very rare. For many years, the American public has been educated to avoid elevators in case of fire due to the possibility of mechanical malfunction and entrapment of the equipment. Today's typical evacuation plan for a high-rise building instructs residents to never use the elevators during a fire (Occupational Safety and Health Administration [OSHA], 2003). In addition, most buildings with fire protection systems have the elevator designed to automatically go out of service when the detection system is activated. In recent years, however, this concept is being challenged as advances in elevator technology are making this option viable (Allen, 2003). As fire officials begin to promote this option in future years, the biggest challenge will be to make an attitudinal change in the minds of the public that will encourage use of elevators during fires.

Fire safety engineers once held the belief that people would turn back when encountering smoke; in reality, researchers have found that people will move through terrible smoke if they feel they must in order to survive (Groner, 2005). In addition, decisions to evacuate are usually reached by a group, including which exit will be used, pace of movement, and whether to follow civility norms.



### High-rise Evacuation Trends

The record of fires with resultant life and property loss emphasizes the need for fire officials, building managers, and residents to initiate and maintain plans for fire response in elderly high-rise living facilities. In recent years, many cities have begun to address this risk by developing effective fire safety and evacuation plans, built through an understanding of the relationship of potential hazards and appropriate response actions. Because of differences in design, construction, height, floor layout, and fire protection systems, the NSC recommends that each building have its own unique plan (2005). In addition, local building, fire, and life safety codes and regulations must also be addressed for compliance in the planning phase.

Planning for successful occupant response revolves around organization and supervision, typically involving these basic areas:

- Building evacuation organization
- Evacuation policy and plans
- Detection and reporting of fire
- Evacuation program coordination
- Communication to direct movement of occupants
- Inspection and evaluation

Emergency evacuation plans should be in written form and reviewed on an annual basis. Mutually-agreed upon priorities, including responsibilities and authorities should be identified. Building management and tenants should cooperate in an education and training program for fire response. OSHA and the NSC have identified basic components that should be a part of any high-rise evacuation plan:

- Post floor plans on all floors showing at least two means of egress

- Identify and train floor wardens, including back-up personnel for sounding alarms, insuring residents have been notified, and assisting and accounting for residents
- Conduct emergency evacuation drills periodically to test response.
- Identify residents with special needs or disabilities who may need help evacuating and assign individuals to assist them. Maintain a list of these individuals for easy accessibility by emergency personnel and update periodically.
- Test all fire protection equipment regularly, including fire detection and alarm equipment, sprinkler and standpipe systems, emergency power and lighting units, automatic fire doors, and building communication systems.
- Identify potential safe areas where occupants can seek refuge if evacuation is not possible.
- Install key boxes or other similar equipment to allow fire personnel access to elevator controls, sprinkler valves, and resident rooms.

When developing emergency action plans in high-rise buildings, two basic response strategies can be implemented: evacuation or shelter in place. The choice of strategy is influenced by several factors including building construction, the ability of residents to effectively self-evacuate, the size and location of the fire, the ability of authorities to communicate directives to occupants, and the capabilities of the responding fire department to mitigate the incident. Often, a mixture of evacuation and sheltering in place strategies will be the best solution to provide for the safety of occupants. Dunn (1999, May) believes that fire departments must implement a defend-in-place strategy at high-rise fires because there are usually too many people in these buildings to expeditiously evacuate the entire building. He

advocates tactics to quickly bring the fire under control, minimizing the need for a full evacuation.

The construction of the building will be an important factor in considering the decision to defend-in-place. This option is particularly viable in structures of fire-resistive construction where the compartmentalization and protection systems limit the spread of fire and smoke that is found in non-combustible and wood frame structures. Bryan (1995, August) stresses the importance to not solely rely on fire-resistive construction to adopt defend-in-place strategy. Other factors, such as the protection equipment, staffing, management, fire behavior experience, and available tactics must also be taken into account.

A life safety strategy involving both defend-in-place and partial evacuation is the best solution in many cases for fires in high-rise structures. Cooley (1984, April) identifies four stages of the evacuation process:

- Initial area evacuation – if the involved area is separated from other areas with fire-rated walls and doors of at least 1-hour construction, an adequately staffed fire response will limit evacuation needs to moving occupants in the immediate area to safer rooms on the same floor.
- Wing or horizontal evacuation – for buildings compartmentalized by automatic fire doors, endangered occupants can be moved to uninvolved wings on the same floor. This will need to be coordinated with firefighting operations to maintain integrity of the occupied wings.
- Floor or vertical evacuation – when there are no safe areas on the involved floor due to extensive fire and smoke conditions or a lack of fire protection systems, such as rated construction assemblies or fire doors, the entire floor may need to be evacuated.

As conditions deteriorate, adjacent floors, especially the floor directly above the fire, should also be considered for evacuation. Most experts (Dunn, Bryan, P., and NSC) promote an evacuation of occupants to two to three floors below the involved floor. Upward evacuation should only be considered if moving occupants to lower floors is impossible.

- General or total building evacuation – should the incident threaten the safety of all occupants, such as a potential explosion, collapse, or fire on a lower floor, to a degree that removing them from the building is the only option, a total evacuation should be initiated immediately.

In order to increase the efficiency and speed of the evacuation process, a triage system should be used to identify priorities for moving victims. Victims who require only simple emergency care or those who are uninjured should be evacuated first. Those who need emergency care but whose survival is not dependent on immediate care should be next, followed by victims whose chance of survival depends on immediate emergency care. The lowest priority is given to those who are obviously deceased.

#### New Technology and Engineering Controls

Advances in technology and improved building systems continue to make high-rise living safer in the 21<sup>st</sup> century. Computer-modeling of evacuation plans that reflect predictions for occupant behavior will enable researchers to simulate real world conditions, providing fire officials to build better evacuation schemes for moving people during fire alarms in these facilities (Page, 2004). New studies are currently underway that illustrate the urgency of developing better building evacuation plans following the World Trade Center attacks and The Station nightclub fire in Rhode Island. One example, Project HEED, which stands for High-rise

Evacuation Evaluation Database, involves the interview of over 2,000 survivors of the World Trade Center disaster (Smith, 2004). The results of this study could significantly alter the next generation of performance based building codes and high-rise building design.

Sprinkler and standpipe systems, currently required under most fire and building codes, provide for suppression of a fire in its early stages as well as a water conduit for extinguishment by responding fire companies. In addition, they are the best means of suppressing and controlling the deadly smoke that claims the greatest percentage of lives in these buildings. Fire alarm and detection systems, emergency lighting, automatic fire doors, and building communication systems are also basic components of a total high-rise safety package. There are many other engineering controls that can be effective in enhancing the fire protection for high-rise residents.

Recent advances in technology make evacuation by elevator in high-rise buildings a more viable option. In accordance with the National Safety Code for Elevators and Escalators (American Society of Mechanical Engineers [ASME], 2005), automatic devices, known as Phase I and Phase II operation, typically recall all elevators to the lobby or other designated floors when the fire alarm is activated in the building. During the early stages of a fire, however, elevators continue to operate normally. Evacuation during this critical time is a viable option, especially for elderly residents with mobility impairments. An Early Evacuation Elevator Operation (E3 Operation) can be implemented using the existing connection between the building's fire alarm system and the elevator control systems. Evacuation zones can be established based on the location of the activated detection device. These zones usually involve at least the fire floor, floor above, and the floor below. During E3 Operation, signals from persons calling the elevator to floors outside the evacuation zone are overridden in favor of those

in the threatened zone. With the activation of detectors in the elevator lobby or control room, the elevator is immediately recalled to the lobby by Phase I Operation and is unusable until Fire Department arrival. By using the window of opportunity in the initial stages of a fire to move both able-bodied and mobility-impaired residents to a place of safety, Allen (2003) believes that E3 Operation could have immeasurable rewards.

Multi-story buildings often are designed with a means of controlling smoke in the event of fire through the heating, ventilation and air conditioning (HVAC) systems. These systems can be designed to exhaust the smoke or circulate fresh air through the building. For buildings with central HVAC systems especially, the best answer is to have the system automatically shut down under fire conditions. This prevents smoke from moving throughout the building ductwork and allows fire personnel to manually control it. Controlling smoke in the exit is also very important. In some buildings, openings from the stairwell to the outside provide for open-air smoke removal. Other designs call for a means of pressurizing the stairwell with air to prevent smoke from entering the stairs. Bryan (1995, August) notes that in actual emergencies pressurized stairs have not been particularly successful and suggests that fire personnel should expect problems with these designs. Proulx (2003) agrees that these systems may not be effective when several doors on different floors are opened simultaneously, as in a full evacuation. Another smoke control method involves smoke dampers that automatically control smoke within the HVAC ductwork. By controlling the smoke in the structure, fire officials are better suited to implement defend-in-place strategies and are not faced with a time and manpower-consuming effort of a total evacuation.

The design of the stairwell itself can contribute to the enhancement of evacuation capabilities. For many years, a nominal 44 inch stair width has been used in high-rise buildings.

Though the premise behind this width is that two people can readily move abreast in a unidirectional flow and that passing can occur, Pauls (2003) finds that this is rarely the case. Based on studies in buildings with stair widths of 36 to 60 inches, he found that a minimum of 48 inches allows people to pass, and recommends stairs should be at least 56 inches for optimum flow.

Persons with disabilities offer unique challenges to building engineers and fire safety officials. Special evacuation chairs are an option for those incapable of navigating down stairwells. These can be stored in a designed location in or near the stairwell for use by residents or fire personnel. Though some fire departments believe that evacuation chairs can jam up the stairwell, Kailes (2002) confirms that this is not the case, as was proven during the World Trade Center disaster. Two wheelchair users escaped using evacuation chairs with inexperienced helpers. Others who waited to be rescued – died (Byzek, 2001). For those with hearing problems, sound monitor systems with vibrating units that receive signals from many types of transmitters, including smoke alarms, are available with options involving strobe lights.

In cities that have high-rise structures, fire departments maintain aerial ladder apparatus with the idea of rescuing persons trapped on upper floors during fires. The Insurance Services Office (ISO) gives maximum ladder company credit in its rating schedule for aerial capabilities of 100 feet in those municipalities with buildings of at least that height (Hickey, 2002). However, these vehicles, which can be extremely expensive, should not be counted on to a great degree in planning for high-rise evacuation. Dunn (1999, May) writes that the methods of safely removing occupants endangered by fire or smoke in high-rise structures are: first through a horizontal exit, second by an enclosed stairwell, and third by a fire escape. Only if these are not available, should a fire officer consider the use of an aerial device. The use of an aerial ladder or

platform is compromised by the access to the occupants of the building, the time and manpower required to set the ladder up and perform rescues, and the willingness of the residents to maneuver themselves onto the aerial device. The fact that most fire departments that protect high-rise structures have the potential to operate at emergencies that involve creative and unique rescue scenarios involving last resort efforts attributes to the existence of aerial apparatus in their communities.

The literature review suggests that understanding and predicting the behavior of residents is a key factor in the planning process for high-rise safety and evacuation. It is to be expected that elderly residents will have life experiences that will greatly influence and possibly entrench the actions they will take when a fire alarm sounds. Disabilities will also play a key role in the response of the elderly residents and fire department operations will need to plan for problems that these inabilities will present. Fire personnel should also understand the role expectations that residents will have of them and whether those expectations are deserved. It appears there is a wealth of literature available on which to model safety and evacuation plans as well as new technologies on the horizon to further protect elderly residents in high-rise living arrangements.

### Procedures

The study used a descriptive methodology to characterize the current and predicted behavior of elderly high-rise residents during fire alarms in Galesburg. Based on information gathered from the literature review, the author developed a survey to collect behavioral response data from the elderly residents of high-rise buildings in Galesburg. The author believes that by gathering insight into the location and behavior of occupants that would be typically found during alarms at these buildings, the fire department would be in a better position to determine strategy for these occupants' protection.



Respondents were asked to answer 15 questions about their current living situation, their ability to hear and interpret fire alarms, the action they would take in response to fire alarms, and their physical limitations if faced with evacuation. A comments section was also included to elicit additional information from residents concerning fire alarms in their buildings. The author attempted to make the survey short and to the point, due to the targeted population of elderly individuals. Questions were purposely designed to elicit yes/no or short multiple choice answers. A large font size was used to aid elderly residents in reading the questions.

A cover letter was attached to each survey to explain the need and purpose of the study, provide directions and contact information for completing and returning the survey, and assure respondents that responses would be kept confidential. Respondents were asked to respond to questions in accordance with the behavior they would actually exhibit during fire alarms, regardless of whether or not the action would be deemed inappropriate by others. The author was reluctant to include any language that would bias the results of the survey by persuading respondents to answer in any way other than what actual behavior would indicate. A copy of the cover letter and survey can be found in Appendix B.

Initially, four high-rise buildings were selected for involvement in the survey. Moon Towers, Mary Allen West Tower, Galesburg Towers, and The Kensington. These four apartment complexes house the bulk of elderly residents found to live in buildings over six stories in height in Galesburg. Other residences in the city would not fall under the high-rise designation or were not considered elderly housing. Permission was obtained from building management to conduct the survey in three of these buildings. Management personnel at Mary Allen West Tower, however, were under the impression that residents might be confused and misinterpret the survey as a sign that there was a fire protection problem in the building. They

were reluctant to approve of the survey distribution. Therefore, the author decided to eliminate Mary Allen West Tower from the survey.

The surveys were hand-delivered by the author to 302 apartments at Moon Towers, Galesburg Towers, and The Kensington on April 4<sup>th</sup> and 5<sup>th</sup> of 2005. These were draped over the doorknobs of the apartment doors in most cases; some were put in the resident in-boxes found on the outside of the apartment door in others. Residents were given approximately 10 days to respond and place the completed survey in a receptacle in the manager's office at the respective buildings.

Some limitations were noted as to the applicability of the collected data. Elderly people have a higher chance of difficulties in reading, comprehension and understanding of questions asked. It is also possible that some answers were not reflective of the respondent's actual behavior, but rather what the individual thought was a "right" answer. What a person writes or says he or she would do may not always be consistent with the behavior during an actual fire alarm. Others may not be fully aware of their abilities or limitations in maneuvering down stairwells and may over or underestimate this factor. In other cases, pride or fear of others finding out about a person's use of medication or physical limitation may skew the data.

Perhaps the best reflection of actual behavior by residents during fire alarms can be seen during fire drills. Barring the use of sophisticated video equipment, it would be nearly impossible for researchers to be in place to monitor behavior when an actual alarm occurred. Fire drills, however, give a good indication of what can be expected during actual alarms, especially those of the unannounced variety. However, the risks associated with surprise drills in elderly, high-rise housing make this type of drill impractical. In this study, building managers were reluctant to allow drills without preparing residents with prior warning. Therefore, the

author decided to conduct an announced drill at Galesburg Towers to get a different perspective on resident behavior. The size and layout of this facility allowed for the author and a small crew to monitor and record occupant behavior during the drill.

On March 24, 2005, the author and six Galesburg Firefighters conducted the drill at Galesburg Towers at 1000 hours. Occupants had been informed by building staff of a pending drill two days in advance. A firefighter was stationed at the center stairwell on each floor in order to observe occupant response. Each firefighter was provided a form to record findings. A copy of the form can be found in Appendix C. Maintenance staff activated the fire alarm and behavior was observed and recorded. The alarm was allowed to sound for five minutes. This time length was chosen as it is the typical maximum time needed for fire dispatch to receive an alarm, respond, and begin fire operations on scene. There was no “all clear” given (as is normally the case in this building). Firefighters interviewed all occupants who had left their rooms. They also knocked on each apartment door to interview those who had not left their apartments.

The data collected in the drill is limited by several factors. The alerting of the occupants of an impending fire drill imposed some bias on the observed behavior. The time of day also influences the behavior of elderly occupants. One could expect somewhat different behavior at other times of the day, based on the routine of the residents. Others are simply gone from the building at this hour of the morning. Visitors found in the building were not included in the statistics.

A literature review was conducted to evaluate what others have found successful in fire safety and evacuation programs for high-rise buildings. The author attempted to synthesize these into a direction for improving conditions in the four buildings in Galesburg. New engineering

technologies were also investigated to seek out ways of improving the physical aspects of the buildings to improve the fire protection and evacuation capabilities in the facilities.

### Results

A total of 192 of the 302 (63.6%) surveys were returned by residents of the three high-rise facilities. The compiled data is displayed in Appendix D. The average age of survey respondents in the three buildings ranges from 63.7 (82 respondents) at Moon Towers (MT) to 85.7 (19 respondents) at The Kensington (TK). Respondents from Galesburg Towers (GT) average 74.6 years in age. All buildings have a high percentage of residents living alone as only 11 total residents noted that they lived with another person. At MT, only 1 of 82 responding residents had not experienced a fire alarm and only 3 believed they would have trouble hearing the alarm. Of the 91 responding residents at GT, 7 could not say they had heard a fire alarm in the past and 9 thought they would experience difficulty hearing the alarm when it sounded. The situation at TK was quite different. Less than half of the 19 respondents have experienced a ringing fire alarm there, a fact that contributes to only 31% of them being able to respond that they could hear an activated alarm while in their rooms.

#### Question #1. What is the current behavior of elderly residents during fire alarms at high-rise facilities in Galesburg?

Response figures reveal the anticipated actions of elderly residents during fire alarms would be generally consistent at the three facilities. In a vast majority of cases, responding fire personnel would find residents either remaining in their rooms or moving to the stairwell when the fire alarm sounds. At GT in particular, 81.3% of respondents plan to leave their apartments and evacuate to the stairwell compared to 58.5% who would employ that plan at MT. Most of the remaining residents at these two facilities plan to stay in their rooms. Only 5 residents in the

three occupancies expressed a plan to evacuate by the elevator during alarms. The older residents at TK expressed more diverse and less decisive opinions; more than 1 in 5 (21.1%) were not sure what action they would take during alarms while 47.4% would go to the stairwell and 31.7% would stay in their apartments.

Respondents demonstrate a variety of methods to know when it is safe to return to their normal activities following a fire alarm. At MT, 70.7% of residents felt it was safe to go back about their business when the alarm stopped sounding, but only 40.7% of GT residents and 21.1% of TK residents believed this. At GT, nearly 3 of 4 residents (73.6%) would rely on the Fire Department to inform them of the all-clear and about half (47.3%) would trust the building staff to inform them. This compares to 47.6% and 20.7% respectively at MT; 63.2% of TK respondents would trust the fire department to give the all-clear and 57.9% would follow the advice of the building staff. In all buildings, about 10% of residents would know it was safe when another resident said so. The fact that they did not see smoke or flames was not a strong motivator (18.2%) for people to disregard the fire alarm in all three of these buildings.

Just over one-fourth of residents in all buildings use medication to help them sleep. Of those who had trouble hearing alarms, five noted in the comments section that this was during sleeping hours, suggesting a possible connection between their medications and hearing ability.

The author found surprising results in the ambulatory ability expressed by respondents. A total of 20 residents at MT and GT noted they are unable to walk by themselves and 41 could not evacuate alone via the stairwell. Despite an average age of almost 86 years, all survey respondents at TK claimed to be capable of walking alone. However, over one-fourth (26.3%) of these same people at TK would be incapable of getting down the stairwell to the first floor alone.

At MT, one-third of respondents would be unable to maneuver the stairs alone compared to 15.4% at GT.

A large discrepancy was found in response to residents notifying others when they are leaving the building. At TK, 15 of the 19 (78.9%) respondents noted that they tell someone in the building when they are leaving. Slightly less than half (42.9%) of the residents do this at GT and only about 1 in 5 (20.7%) of MT residents can be accounted for by this system.

Of the 192 respondents of the survey, 86 (44.8%) claimed to know how to activate a fire alarm in their building. This number was spread fairly evenly in the three buildings and probably does not greatly correlate much to the behavior of residents during alarms. A total of 156 respondents (81.3%) expressed a willingness to attend informational meetings to discuss fire safety and evacuation planning in all buildings.

Results of the fire drill conducted at Galesburg Towers on March 24, 2005, can be found in Appendix E. A total of 99 of the 120 residents were in the building at the time of the alarm. This did not include any non-resident building staff or fire personnel present during the drill. Of these 99 residents, 61 (61.6%) exited their apartments in response to the fire alarm. All but two of these 61 individuals (59.6%) proceeded to the stairwell. The remaining two attempted to evacuate via the elevator which had been called to the first floor and locked there by Phase I emergency elevator controls. After waiting at the elevator for approximately 3 minutes, they also went to the stairwell.

The first resident exited her room approximately 45 seconds after the sounding of the alarm. A majority of occupants who evacuated did so between the 2 and 4-minute mark of the drill. A total of 13 (14.9%) residents investigated the alarm by opening the door to their

apartment and checking the hallway. These occupants did not, however, evacuate as most returned to their individual apartments or remained in the hallway talking with other residents. Upon interviewing, 4 residents (4.1%) claimed they did not hear the alarm (2 were from the same apartment). There were 7 residents (7.1%) who decided not to evacuate because of physical impairments or disabilities; 3 of these were in wheelchairs and 4 made use of walkers. An elderly female related that she thought the sound was a vacuum cleaner. The two blind persons in the building, one on the 2<sup>nd</sup> floor and the other on the 5<sup>th</sup> floor did not leave their apartments. However, the blind gentleman on the 5<sup>th</sup> floor stated he would have gone to the stairwell, but he was not dressed at the time of the alarm and did not want to expose his body to any female occupants in the hallway. He was able to communicate to the interviewer the correct number of doors and turns to the center stairwell.

In addition, 12 residents chose to stay in their apartments behind closed doors during the drill. A husband and wife in the same apartment related that they would have left by the stairwell if it was a real fire. Another elderly lady claimed she just wanted to die in her own apartment. Others had decided to shelter-in-place. Some of these gave the interviewers the impression that they simply did not wish to be bothered.

Question #2. What have others done to improve evacuation of elderly residents in high-rise buildings?

The literature review confirms the need for fire and building officials to be proactive in preparing for disasters in elderly high-rise residences. There must be written safety and evacuation plans for fire personnel to deal with the behavior of residents during fire alarms. These plans must be unique for each building to take advantage of built-in protection systems, while complying with local building and maintenance codes. Best-case scenarios involve

buildings composed of fire-resistive construction to allow fire officials the ability to choose shelter-in-place strategies that limit commitments of time and resources.

Fire officials need to work with building staff to identify those residents with special needs, such as physical and mental disabilities. Safe areas can be identified within buildings as an alternative to protecting these and other individuals. Building communication systems allow officials to direct occupants to desired evacuation routes and give fire personnel a means of talking with each other.

Fire prevention officers and inspectors should conduct routine inspections in high-rise facilities to check protection systems and safeguard against hazardous conditions that may lead to fire. Many buildings use a system of assigning floor wardens to conduct in-house inspections and act as accountability personnel during fire alarms. By conducting routine and surprise fire drills, residents will become familiar with patterns of good-behavior and understand their capabilities and limitations during actual fires.

Fire personnel can be trained in the use of evacuation triage to more efficiently respond when a full evacuation is called. They should also be schooled on the different levels of evacuation and know what level of resident movement and protection is required given the degree of the hazard. Fire personnel should also be involved in full-scale drills in order to become familiar with the building systems, occupant behavior, and limitations they will find in a real situation.

Question #3. What new technology or engineering controls are available to improve high-rise safety for elderly residents?

There is much that can be done to improve fire protection in high-rise buildings. To date, sprinkler and standpipe systems offer perhaps the best solution to protecting occupants by



limiting the spread of fire and smoke in a building, especially when coupled with early detection and alarm devices. Three of the buildings in the study have sprinkler systems and all have fire standpipe systems. The Kensington (TK) does not have a sprinkler system on the resident floors. In addition, compartmentalization with fire doors, emergency lighting, and building communication systems can aid in evacuation efforts. All buildings have fire doors and emergency lighting, but only Mary Allen West Tower has a building communication system and it has not been in service for many years.

In some cases, technology is out-pacing the ability of the public to accept changes in behavior toward fire alarms in these structures. This is especially true for elderly residents. E3 elevator operation is an exciting new option for moving disabled residents during the early stages of a fire in a high-rise building. However, the fire service will be challenged by long-held axioms regarding the use of elevators by the public during fire alarms and it may be many years before the necessary marketing of E3 elevator engineering will cause the attitudinal change to allow this option to become viable. Three buildings have emergency elevator features that include recall of elevators to the first floor on alarm and override capabilities within the car for fire department use. Galesburg Towers has only the recall feature, likely because it is only 6 floors in height.

Computer-modeling will enable planners to create enhanced evacuation schemes for merging occupant behavior patterns with fire protection systems. This will include new ways to move smoke by improving existing HVAC controls such as smoke dampers and pressurized stairwells. In Galesburg, HVAC systems shut down on alarm in most buildings, except at Mary Allen West, where pressurized stairwells are activated on alarm to keep smoke out of the exit. Evacuation chairs can be stored near the stairwell to assist in the transport of physically impaired

individuals, especially those in wheelchairs. None of the high-rise units in Galesburg have evacuation chairs available.

For those with hearing or vision problems, new systems that make use of vibrating receivers and strobe lights are available to warn users of fire alarm activations. In new buildings, stairwells should be designed to accommodate better traffic flow. A minimum width of 48 inches with a recommendation of 56 inches will help evacuees to move two abreast or pass in the stairwell. Existing buildings, such as the ones in this study, often find this design lacking. The scissor stairwells at Mary Allen West Tower are 44 inches wide on the main stair, but only 40 inches wide at the turns. Even worse, the stair width at MT is a mere 38 inches wide with only 32 inches between the handrails. Two persons of normal size would find it difficult to pass on these stairs.

### Discussion

Many of the findings of this study are consistent with those found in previous studies. Residents who evacuated during the fire drill at Galesburg Towers did not demonstrate any degree of panic which is reflective of the opinions of Marchant (1972), Winerman (2004, September 8), and Gershon (2003). The reaction time for most evacuees to leave their apartments demonstrates that residents did not believe they were in any immediate danger. None of the residents immediately stopped what they were doing and exited their rooms. As expressed by Proulx (2003) and Brennan (1995), individuals will typically treat a fire alarm as ambiguous and will take an average of three minutes to begin to evacuate. Drill evaluators at GT noted that a majority of evacuees left their rooms between 2 and 4 minutes after the sounding of the fire alarm. Some of the “pre-movement” time identified by Proulx was seen in the drill as residents

opened apartment doors to check the hallway in search of other cues or gathered belongings before leaving.

Groner (2000) noted the altruistic behavior of people who checked on neighbors. This activity was not witnessed to a significant degree in the drill as virtually none of the occupants were seen knocking on neighbors' doors. However, survey results from the three buildings paint a somewhat different picture. Though only about 1 in 5 (20.7%) of the MT respondents marked that they notify someone when they leave the building, approximately 4 in 5 (78.9%) of the residents at TK say they inform others when leaving the building. This may be due to the fact that TK residents are provided food service – they eat all their meals in a common dining room. This would support the opinion of Gershon (2003) that altruism is linked to familiarity.

There is apparently little problem associated with hearing the fire alarm at MT and GT. However, the apparent lack of alarms at TK in association with an older group of residents who may be using medication to assist with sleep may point to a problem of individuals not hearing or recognizing the fire alarm.

It appears the fire personnel responding to alarms in Galesburg could expect to find residents in one of two places on arrival. A majority of people will be found in the stairwell with the remaining number staying in their rooms. The use of elevators during fire alarms was found to be almost non-existent in both the drill and the survey. This is likely due to the great amount of public education by groups such as OSHA (2003) telling people to not use the elevators during fires. Some difference was found in what people will say in a survey and what they do in a drill. Though 81% of GT residents claimed they would evacuate to the stairwell in the survey, only 59% actually did so during the drill. The difference could be accounted for by the drill only lasting 5 minutes.

All the residents who evacuated to the stairwell during the fire drill at GT immediately left the stairwell and returned to their rooms when the fire alarm was silenced. Again, it appears that what people will say in a survey differs from reality. Only 40% of respondents noted they knew it was safe to return to their rooms when the alarm quit sounding. A larger percentage in all buildings marked that they knew it was safe when fire personnel informed them. However, this is not the case in reality in Galesburg. It appears the lack of a communication system in all of these buildings has led the tenants to believe it was safe to return to their apartments when the alarm stopped. This action supports the belief of Brennan (1995) who reasons that if a threat is ambiguous, a person will assume it to be mild as individuals tend to ignore or deny an unexpected and unpleasant event that has happened. The continued reinforcement of this behavior by both fire personnel and building occupants could have disastrous consequences.

There were no persons with walkers or wheelchairs who attempted to evacuate their rooms during the fire drill at GT. When interviewed, all those with walking impairments stated they planned on waiting in their rooms for assistance from others. None had made plans with neighbors or building staff to assist them in case of alarm. This attitude was most evident in the elderly female who claimed she just wanted to die in the comfort of her apartment. This attitude runs contrary to the advice of Kailes (2002) who stresses the importance of elderly adults with physical impairments having action plans in place to facilitate their evacuation.

A large share of survey respondents noted they would attend an informational meeting to learn more about actions to take in their building during fires. This is very encouraging, especially since little has been done to this point in the way of evacuation planning in any of the buildings. Other than the occasional accidental fire alarm, none of the buildings conduct regular fire drills to evaluate the response of occupants and improve methods. The alarm history noted

in Appendix A demonstrates the frequency of mishaps that occur in these structures. Many of these are caused by careless cooking or smoking by the elderly residents. The author believes one of these mishaps will eventually develop into a sizeable fire that will threaten a large number of occupants. One can imagine that a better system of protection would likely be in place if these buildings housed young children rather than older adults. The author believes there would be a tremendous outcry for better fire safety and evacuation planning in these high-rise structures.

### Recommendations

The study shows there is a need for fire officials and building managers to cooperate in developing much needed fire safety and evacuation plans for the elderly housing in high-rise buildings in Galesburg. At the present, the behavioral response of residents to fire alarms is predictable, but does not follow any fire protection or evacuation strategy. Although existing fire protection systems appear adequate, the lack of plans to deal with the coordination of the “people factor” pose a community risk that must be addressed in the near future. In order to improve the situation, the author makes the following recommendations:

- Create awareness of the need for better evacuation and safety planning in high-rise residence buildings.
- Educate residents in high-rise fire safety and evacuation policies. Explain actions for shelter-in-place as well as full and partial evacuation strategies. Continue with general fire safety presentations to residents which to include issues with cooking and smoking.
- Schedule regular inspections of all high-rise facilities yearly to include protection systems, detection systems, and elevators.

- Schedule quarterly fire drills to evaluate behavioral response of residents. Conduct these drills in coordination with fire response on an annual basis.
- Implement a system for accounting for building residents during fire alarms. Assign floor wardens and maintain lists of those who plan to shelter-in-place with special attention to those with disabilities who will require assistance.
- Investigate the possibility of installing a building communication system. This will greatly improve tactics for partial evacuation and shelter-in-place zones. It will also be useful in providing critical information to all residents including when it is safe to return to normal activities. If not possible, develop another system in cooperation with residents to signal “all-clear”.
- Investigate potential areas of refuge in each building that could be useful when a full evacuation is not possible.
- Make provisions for storing evacuation chairs throughout the different levels of the building. Assign able-bodied residents who could assist non-ambulatory individuals down stairwells.
- Provide access to a sufficient number of master keys for fire personnel to quickly gain entry to locked apartments to search for occupants.
- Post floor plans with evacuation routes on all floors. Coordinate these plans with predicted actions of responding fire personnel to allow for better movement of both.
- Investigate the feasibility of installing E3 Emergency Elevator Operations to coordinate with the detection system in all buildings. This heightens the ability of residents to self-rescue during the critical window of opportunity.

- The Galesburg Fire Department should practice and evaluate aerial ladder operations to preplan response capabilities of its ladder platform at all buildings.
- Explore products for meeting the needs of vision and hearing impaired individuals to enhance their safety during fire alarms.

These recommendations have the potential to greatly improve the chances of surviving a fire for elderly residents in the four high-rise buildings in Galesburg. The author will need to convince fire management that the time and resources necessary to make these improvements will lessen the risk to the public. Future researchers will need to evaluate the success or failure of E3 Emergency Elevator Operations to determine its viability in saving lives. They will also need to continue computer-modeling to fully understand and predict human behavior during fires. There is a great risk associated with housing elderly individuals in high-rise structures. Fire service leaders must continue to search for better answers to the challenge of protecting those at risk.

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## Appendix A

*Fire Alarms in High Rise Buildings, 2001 through 2004*

	Total Fire Alarms	False Alarms	Actual Fires
Moon Towers	31	25	6
Galesburg Towers	9	8	1
Mary Allen West Tower	11	7	4
The Kensington	5	5	0
<b>Total</b>	<b>56</b>	<b>45</b>	<b>11</b>

False alarms category includes unintentional human error, alarm system malfunctions, and intentional false alarms.

## Appendix B

## Survey of High Rise Residents Responding to Fire Alarms (Cover Letter)

TO: All High-Rise Residents in Galesburg  
FROM: Battalion Chief Tom Simkins, Galesburg Fire Department  
(309) 345-3756  
DATE: April 4, 2005

Dear Resident:

I am conducting a study on actions residents take during fire alarm activations in high-rise buildings in Galesburg for a class at the National Fire Academy. I could really use your help!

I have attached a survey form that I would like for you to fill out and return to me. All answers will be kept confidential. Please answer truthfully, according to your intended and actual response to fire alarms in your building. I am not looking to find fault with any of your responses. The information you provide will help the Galesburg Fire Department plan our response should an unfortunate event occur in your building.

Please **return the attached form to the manager's office in your building** by April 15, 2005.

Thank you very much for your help in this study.

## Appendix B (cont'd)

## Survey of High Rise Residents Responding to Fire Alarms

1. I live in this building (please check):  
☐ Moon Towers  
☐ Galesburg Towers  
☐ The Kensington
2. I am  years old.
3. I live: ☐ alone ☐ with another person
4. I have heard the fire alarm sound in my building in the past.  
☐ Yes ☐ No ☐ Not sure
5. If the fire alarm sounds while I am in my room, I (please check one)  
☐ can hear the alarm.  
☐ have trouble hearing the alarm.  
☐ cannot hear the alarm.
6. When the fire alarm sounds, I  
☐ stay in my room.  
☐ leave my room and go to the elevator  
☐ leave my room and go to the stairwell  
Other
7. After the fire alarm sounds, I know it is safe to return to my normal routine when: (check all that apply)  
☐ the alarm stops sounding.  
☐ I don't see any smoke or flames.  
☐ another resident tells me there is no problem.  
☐ the building staff tells me it is safe.  
☐ the Fire Department tells me it is safe.
8. I take medication to help me sleep. ☐ Yes ☐ No

9. I am able to walk by myself. \_\_\_\_\_ Yes \_\_\_\_\_ No
10. I am able to get to the elevator by myself. \_\_\_\_\_ Yes \_\_\_\_\_ No
11. I am able to get to the stairwell by myself. \_\_\_\_\_ Yes \_\_\_\_\_ No
12. I am able to go down the stairs to the first floor by myself.  
\_\_\_\_\_ Yes \_\_\_\_\_ No
13. I tell a neighbor or someone else in the building when I am leaving the  
building. \_\_\_\_\_ Yes \_\_\_\_\_ No
14. Do you know how to activate the fire alarm in the building?  
\_\_\_\_\_ Yes \_\_\_\_\_ No
15. Would you attend an informational meeting to learn more about what to do in  
case of a fire in your building? \_\_\_\_\_ Yes \_\_\_\_\_ No

Please list any concerns or comments you have regarding response to fire  
alarms in your building:

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THANK YOU FOR TAKING THE TIME TO HELP US LEARN MORE ABOUT  
CURRENT FIRE ALARM RESPONSE BEHAVIOR TRENDS IN YOUR  
BUILDING. WE WILL CONTINUE TO STUDY EVACUATION PLANNING  
IN YOUR BUILDING. WE PLAN TO SCHEDULE EDUCATIONAL  
MEETINGS IN YOUR BUILDING IN THE MONTHS AHEAD.

GALESBURG FIRE DEPARTMENT

## High-rise Fire Drill Form

Floor: \_\_\_\_\_

ADDITIONAL INFORMATION:

[illegible]



## Appendix D

*High-rise Survey Response Statistics*

	Moon Towers		Galesburg Towers		Kensington	
Number of residents	150		122		30	
Number of returned surveys	82	54.7%	91	74.6%	19	63.3%
Average Age	63.7		74.6		85.7	

## 3. I Live

alone	76	92.7%	88	96.7%	17	89.5%
with someone	6	7.3%	3	3.3%	2	10.5%

## 4. I have heard the fire alarm sound in my building in the past.

Yes	81	98.8%	84	92.3%	8	42.1%
No	1	1.2%	6	6.6%	7	36.8%
No Response/Not Sure	0	0.0%	1	1.1%	4	21.1%

## 5. If the fire alarm sounds when I'm in my room, I:

can hear	79	85.4%	82	90.1%	6	31.7%
have trouble hearing	2	2.4%	4	4.4%	2	10.5%
cannot hear	1	1.2%	4	4.4%	4	21.0%
No Response	0	0.0%	1	1.1%	7	36.8%

## 6. When the fire alarm sounds while I am in my room, I:

stay in my room	35	42.7%	15	16.5%	6	31.7%
leave/go to elevator	2	2.4%	1	1.1%	2	10.5%
leave/go to stairwell	48	58.5%	74	81.3%	9	47.4%
No Response/Not Sure	0	0.0%	1	1.1%	4	21.1%

## 7. After the fire alarm sounds, I know it is safe to return to my normal routine when (check all that apply):

alarm stops sounding	58	70.7%	37	40.7%	4	21.1%
don't see smoke/flame	21	25.6%	9	9.9%	3	15.8%
another resident says its ok	11	13.4%	7	7.7%	2	10.5%
bld. Staff says it's safe	17	20.7%	43	47.3%	11	57.9%
Fire Dept. says its safe	39	47.6%	67	73.6%	12	63.2%
No Response	0	0.0%	0	0.0%	3	15.8%

## 8. I take medication to help me sleep:

Yes	21	25.6%	27	29.7%	5	26.3%
No	61	74.4%	64	70.3%	14	73.7%
No Response	0	0.0%	0	0.0%	0	0.0%

9. I am able to walk by myself:

Yes	71	86.6%	82	90.1%	19	100.0%
No	11	13.4%	9	9.9%	0	0.0%
No Response	0	0.0%	0	0.0%	0	0.0%

10. I am able to get to the elevator by myself:

Yes	80	97.6%	83	91.2%	17	89.5%
No	2	2.4%	5	5.5%	2	10.5%
No Response	0	0.0%	3	3.3%	0	0.0%

11. I am able to get to the stairwell by myself:

Yes	78	95.1%	88	96.7%	18	94.7%
No	4	4.8%	3	3.3%	1	5.3%
No Response	0	0.0%	0	0.0%	0	0.0%

12. I am able to go down the stairs to the first floor by myself:

Yes	55	67.1%	73	80.2%	14	73.7%
No	27	33.0%	14	15.4%	5	26.3%
No Response	0	0.0%	4	4.4%	0	0.0%

13. I tell a neighbor or someone else in the building when I am leaving the building

Yes	17	20.7%	39	42.9%	15	78.9%
No	65	79.3%	47	51.6%	4	21.1%
No Response	0	0.0%	5	5.5%	0	0.0%

14. Do you know how to activate the fire alarm in the building?

Yes	42	51.2%	33	36.3%	11	57.9%
No	40	48.8%	55	60.4%	7	36.8%
No Response	0	0.0%	3	3.3%	1	5.3%

15. Would you attend an informational meeting to learn more about what to do in case of a fire in your building?

Yes	63	76.9%	76	83.5%	17	89.5%
No	12	14.6%	12	13.2%	1	5.3%
No Response	7	8.5%	3	3.3%	1	5.3%

## Appendix E

Table E1

*Galesburg Towers Fire Drill Results*

Date: March 24, 2005

	Total	Percent	Floor 1	Floor 2	Floor 3	Floor 4	Floor 5	Floor 6
Exited Apartments	61	61.6	5	15	10	13	10	8
Exited to Stairwell	59	59.6	5	15	10	13	8	8
Exited to Elevator	2	2.0	0	0	0	0	2	0
Invest. Only/Didn't Take Action	13	13.1	0	2	3	0	4	4
Did Not Hear Alarm	4	4.0	0	1	0	2	0	1
Stayed in Room	12	12.1	2	0	4	3	1	2
Not Home	21	N/A	2	3	5	2	3	6
Non-Ambulatory	7	7.1	0	1	3	2	1	0
Other Impairment/Disability	2	2.0	0	1	0	0	1	0